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Summary and Implications

Effect of electron-beam irradiation on the quality of ready-to-eat (RTE) turkey ham was studied. Turkey hams were purchased from local stores and sliced into 0.5 cm-thick pieces and vacuum packaged. The ham samples were randomly separated into three groups and irradiated at 0, 1, or 2 kGy, and stored at 4°C for up to 14 d. Volatiles, color, TBARS values and sensory characteristics were determined. Irradiation had little effects on color and TBARS values of RTE turkey hams. Sensory analysis indicated that sulfury odor increased as irradiation dose increased, and the contents of sulfur compounds in irradiated RTE turkey hams were higher than those in nonirradiated samples. Irradiation increased ($P < 0.05$) the production of acetaldehyde, which could be related to a metal-like flavor in irradiated hams. However, overall quality changes in RTE turkey hams by irradiation up to 2 kGy were minor.

Introduction

The Food Safety and Inspection Service conducted a 10-year microbial prevalence study for ready-to-eat (RTE) meat and poultry products produced from approximately 1,800 federally inspected establishments, and found that prevalence of *Salmonella* ranged from 0.05% to 1.43%; *L. monocytogenes* in sliced ham and luncheon meat was up to 5.16%, and other products ranged from 0.52% to 3.56%. This report clearly shows the seriousness of food safety problem in ready-to-eat meat products, especially for sliced ham. Irradiation is the most effective technology in eliminating these pathogens in meat products. However, irradiation induces quality changes in meats. The objective of this study was to determine the effect of irradiation on the volatiles, sensory characteristics, color, and lipid oxidation of RTE turkey ham.

Materials and Methods

Commercial turkey hams were purchased from local retail stores. Hams were sliced into 0.5 cm-thick pieces and vacuum packaged in low oxygen-permeable bags. The sliced hams from each replication were randomly separated into three groups and electron-beam irradiated at 0, 1, or 2 kGy using a Linear Accelerator. After irradiation, turkey were analyzed.

Results and Discussion

Irradiation decreased color L* values but increased a* values at 0 and 14days. Irradiated turkey ham had higher TBARS values than nonirradiated control at 0 day, but this difference disappeared after 7 and 14 days storage (Table 1). Odor or flavor associated with irradiation off-odor/flavor were metal-like, oxidized, sulfur and sweet. The sensory attribute mostly strongly correlated with irradiation was sulfur odor/flavor and when ham was irradiated at 2 kGy was more intense than nonirradiated control. The presence of sulfur and metal-like odor in irradiated samples was associated with the increased sulfur compounds and aldehydes in volatiles.

Carbon disulfide was detected only in irradiated samples and the amount of dimethyl disulfide was significantly higher in irradiated than that in non-irradiated ham. The content of acetaldehydes was also significantly higher in irradiated samples (Table 2). This could be related to the metal-like odor/flavor as perceived by sensory panelists. The amounts of hexanal and pentanal in irradiated turkey hams were greater than those in nonirradiated hams after 14 days of storage. Irradiation also increased 3-methyl butanal and 2-methyl butanal, which were associated with the radiolysis of leucine and isoleucine, respectively. The increases of alkanes and alkenes in hams after irradiation were also observed (Table 2 and Fig 1).

After 7 days of storage, the contents of carbon disulfide, dimethyl disulfide, acetaldehyde and 1-heptene were still significantly higher in irradiated than nonirradiated turkey hams. After 14 days of storage (Table 2), the amount of sulfur compounds were still higher in irradiated than that in nonirradiated samples, but the difference in acetaldehyde disappeared. During storage time, the content of aldehydes in nonirradiated samples increased significantly, but no changes were observed in irradiated samples (Fig 1a). Both alcohols and ketones in nonirradiated samples increased significantly during storage, but no change was observed in irradiation samples (Fig 1c and d). For each irradiation dose, the contents of sulfur compounds did not significantly change during storage (Fig 1e).

Conclusion

Up to 2 kGy of irradiation has limited effects on color and oxidation of vacuum-packaged commercial turkey ham; however, irradiation has significant influence on odor/flavor of vacuum-packaged turkey ham. Both sensory panelists and volatiles analysis showed that there were significant changes in sulfur-related odor/flavor in RTE turkey products by irradiation. Thus, future studies should be focused on the

prevention of irradiation-induced flavor changes in RTE meat products.

Acknowledgement

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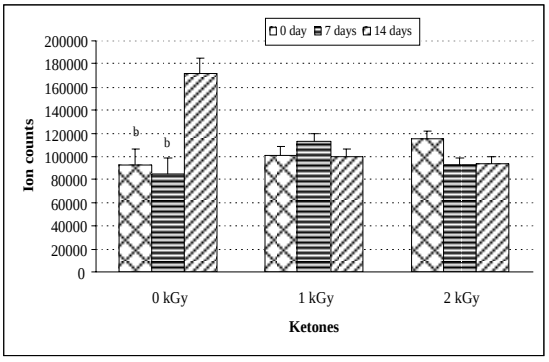
Table 1. Color, TBARS and sensory characteristics of irradiated turkey ham during storage.

	Storage day		
IR dose	Day 0	Day 7	Day 14
	----------*L*-value*----------		
0 kGy	61.1x	61.2	61.6x
1 kGy	60.3xy	61.2	61.2x
2 kGy	58.8y	59.6	59.2y
	----------*a*-value* ----------		
0 kGy	20.9x	20.7	20.7y
1 kGy	21.3x	21.0	20.7y
2 kGy	21.5y	21.1	21.6x
	---------- *TBARS*----------		
0 kGy	0.60y	0.78	0.75
1 kGy	0.74x	0.70	0.68
2 kGy	0.70x	0.72	0.78
	----------*Smell*----------		
Metallic	1.8	1.8	2.4
Oxidation	1.4	2.3	1.4
Sulfury	1.7b	2.4ab	3.0a
Sweet	2.5	2.1	2.3
	----------*Flavor*----------		
Metallic	1.6	1.8	2.3
Oxidation	1.3	1.8	1.8
Sulfury	1.8	1.9	2.8
Sweet	2.4	2.4	2.5

Fig 1. Changes of major volatile groups from irradiated turkey hams during storage.



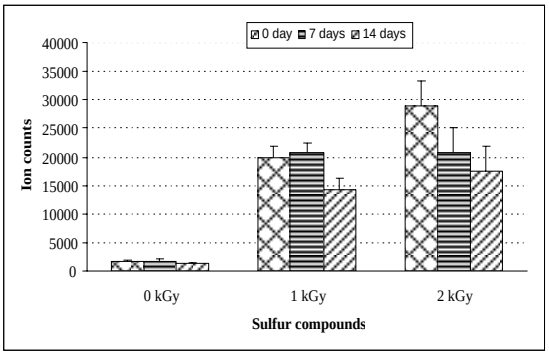


Figure notes: Aldehydes include acetaldehyde, propanal, 2-methyl-propanal, 3-methyl-butanal, 2- methyl-butanal, pentanal, hexanal, 2-methyl-2-pentenal, and n-heptanal; Sulfur compounds include carbon disulfide and dimethyl-disulfide; Alkanes and alkenes include pentane, 1-heptene, 2,3,4-trimethyl-pentane, 2,3,3-trimethyl-pentane, octane, 2-octene, and 3-methyl-2-Heptene; Ketones include 2-propanone, 2-butanone, 2,3,-butanedione, 2-pentanone, 4-methyl-2-pentanone, 3-methyl-2-pentanone, 3-hexanone, 2-hexanone and cyclopentanone; Alcohols include ethanol, 2-propanol, 1-propanol, and 2-butanol.

Table 2. **Volatile profiles of irradiated turkey ham during storage.**

	Day 0			Day 14		
Volatiles	0 kGy	1 kGy	2 kGy	0 kGy	1 kGy	2 kGy
Acetaldehyde	2310c	6140b	10328a	8059	6926	8762
Pentane	0	460	749	0b	0b	634a
Propanal	4342	6050	3464	6074	4602	4904
2-Propanone	34393	36327	34305	48713a	28537b	29717b
Carbon disulfide	0b	10257ab	14499a	0b	9071a	10234a
Acetic acid methyl ester	2664	2073	2227	2992a	2027b	2277b
2-Methyl-propanal	871b	1727ab	2519a	1604	1958	2564
Ethanol	1595	1535	2062	15633	6084	7702
2-Propanol	4421ab	3183b	6417a	4918	4894	5112
2-Butanone	15690	14957	17562	35577	16454	16664
Acetonitrile	1784	1694	1915	2161	1959	2096
2,3-Butanedione	177b	230ab	286a	480	345	342
3-Methyl butanal	1330b	2680ab	3819a	1914b	3046ab	3991a
2-Methyl butanal	1090	2284	2437	1900	2699	3564
Benzene	894	1051	1217	996	958	996
1-Heptene	0c	290b	605a	0b	165b	506a
1-Propanol	3338	1935	2246	396210a	62215b	10656b
2-Butanol	320	229	498	0	138	336
2-Pentanone	888	839	808	0b	988a	937a
Pentanal	0	0	106	0b	1286a	1185a
2,5-Dimethyl-furan	0	49	26	0	71	53
2,3,4-Trimethyl-pentane	168	590	1169	223a	0b	0b
2,3,3-Trimethyl-pentane	328	1052	2669	671a	0b	0b
4-Methyl-2-pentanone	123	125	97	86b	206a	185a
3-Methyl-2-pentanone	0	0	54	0	136	87
Dimethyl-disulfide	1712c	9645b	14468a	1270c	5253b	7297a
Toluene	1049c	1664b	2293a	1162b	1394ab	1677a
Octane	342b	1174ab	1626a	790	745	859
3-Hexanone	187	172	181	72	124	107
2-Octene	98	248	521	211	0	183
3-Methyl-2-heptene	0	243	260	106	34	34
2-Hexanone	180	102	77	192	200	147
Hexanal	486b	1326a	1342a	1520b	2734a	3058a
2-Methyl-2-pentanal				1715	1000	0
Ethyl-benzene	19	68	140	211	159	74
Cyclopentanone	0	0	56	51	60	109
1,3-Dimethyl-benzene	0	83	109	164	78	154
p-Xylene	195	64	58	58	71	0
n-Heptanal	0	0	117	315	475	504
Styrene	77	55	92	189a	165ab	139b
Total	81068	110600	133421	536233a	167193b	127844b